



CS21087

## Interoperability – The Software Unicorn

### Regional Connector Transit Corridor Project

Brindusa Dumitrascu  
Mott MacDonald

Otto E Stallworth III  
Mott MacDonald

#### Learning Objectives

- Understand the Revit Limitations
- Learn how to bring Civil 3D content into Revit
- Learn how to bring Revit content into Civil 3D
- The future of the Unicorn

#### Description

This class focuses on Los Angeles Metro's downtown Los Angeles' current transit project, the Regional Connector Transit Corridor (RCTC). During the design of RCTC several vertical stacks of Autodesk software (Revit, Civil 3D, Navisworks, BIM 360 Glue) were integrated with a variety of other platforms. In this class we will share some of the "secrets" on bringing these programs together with efficient and manageable workflows.

RCTC is a \$1.55 billion underground Light Rail Transit extension that connects Metro's existing Gold Line Little Tokyo/Arts District Station to its 7<sup>th</sup> Street/Metro Center Station in downtown Los Angeles. This connection will serve as a major link to the current and future Los Angeles transit system.

Demonstrating why BIM was the correct choice for the project's design, we will step through our Revit to Civil 3D work flow, outline our Revit to AutoSprink process, indicate how we used Navisworks for clash detection and how we utilized BIM 360 Glue and BIM 360 Field for model viewing.

#### Your AU Experts

##### Brindusa Dumitrascu, Mott MacDonald

Brin is a BIM Specialist for Mott MacDonald. Starting with the company in 2008, in their Vancouver office, she has been based in Los Angeles since 2014. Brin holds a bachelor's degree in Computer Science and Mathematics, a master's degree in Mathematics, and an Associate Certificate in Civil Engineering Technology. Brin's favorite Autodesk Software is Revit – she is a Revit Structure Certified Professional – but she is also familiar with Civil 3D and Navisworks.



**Otto E Stallworth III, Mott MacDonald**

Otto has over 10 years of experience with Autodesk products and he is an experienced designer with a special focus in a rail transit environment and a background in architecture. He is a well-seasoned user in the application of BIM software and currently works as a Design Coordinator for Sydney Metro in one of the Mott MacDonald's Australian offices. He is part of a multi-disciplinary design team supporting project management, systems integration, engineers and architects, and coordinating between all parties. His long-term goal is to become a licensed architect in the State of California.



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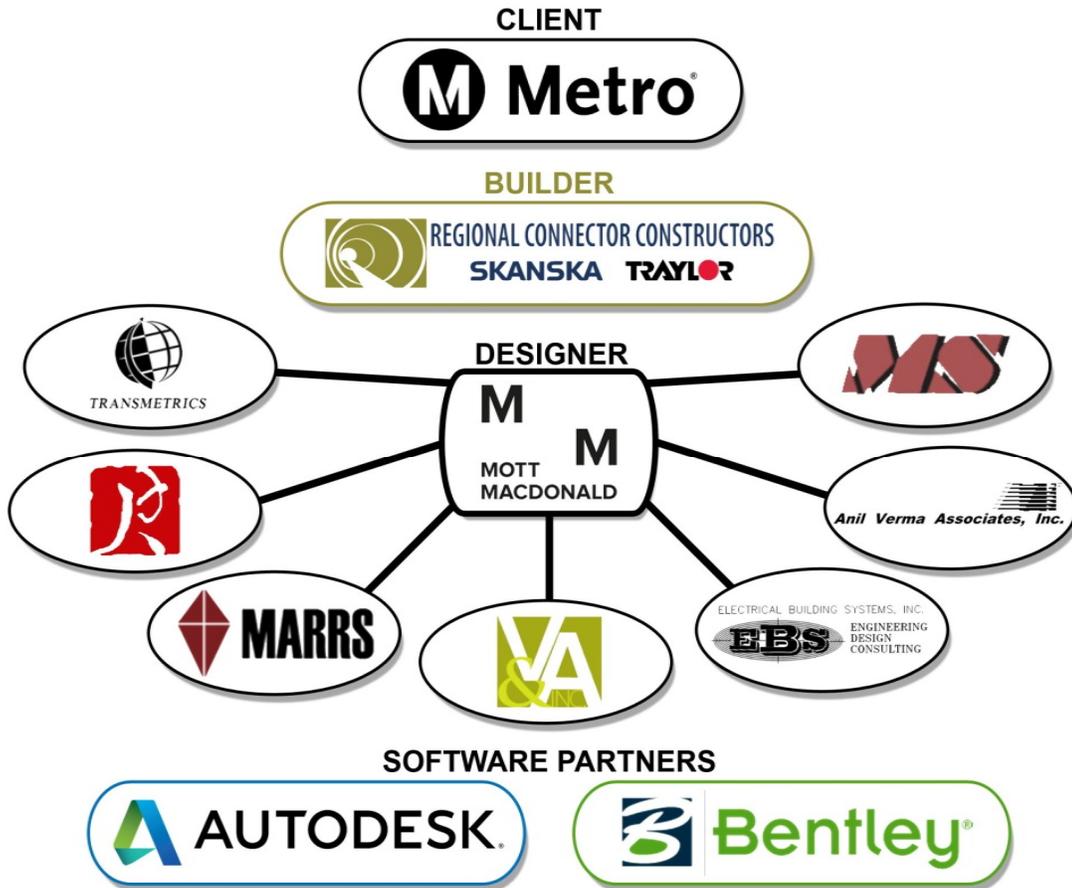


FIGURE 2 – DIVERSE COLLABORATION TEAM

### The Technology Behind the Project

The decision to utilize an Autodesk platform was made at the beginning of the project. Autodesk software, in conjunction with a variety of others, was used to produce the final design drawings. ProjectWise was the chosen file sharing medium. Revit 2014 was selected as the cross-discipline modelling tool for the underground stations. Civil 3D 2014 was used to layout tunnels and create civil and utilities models. Navisworks 2014 was used for clash detection and BIM 360 Glue for model viewing and exhibits. Bluebeam studio was the chosen design review tool for both Mott MacDonald and the contractor. AutoSprink was the preferred software solution for fire protection design within the stations.

Over 150 individual models were created for the project. The modelling load was split between 15 Mott MacDonald offices and 20 sub-consultants working together, as illustrated below. The various models were not only used for final design drawings, but also by the various discipline teams for analysis. For example, Computational Fluid Dynamics (CFD) analysis for the station

ventilation designs were performed using the station Revit models. Structural design of the stations and tunnels also utilized the models, as did mechanical engineers for flow calculations.

Discipline	Qty	MM or Sub	Location(s)
Architectural	3	Subs - 2	Los Angeles RCTC Project office (RCTC)
Structural – 2/H Station	1	MM	RCTC / Buffalo offices
Structural – 2/B Station	1	Sub	Mississauga office
Structural – 1/C Station	1	MM	Seattle / Pleasanton offices
Mechanical - HVAC	3	MM	RCTC
Mechanical – Plumbing	3	MM	RCTC
Electrical	3	Sub	RCTC
Traction Power	3	MM	RCTC / Pleasanton offices
Fire Protection	3	RCC Sub	Los Angeles home office

*TABLE 1 – REVIT MODELS*

Discipline	Qty	MM or Sub	Location(s)
Structural – C&C Flower	1	Sub	Los Angeles home office
Structural – C&C Alameda	1	MM	Salt Lake City office
Structural – Bored Tunnels	1	Sub	Mississauga office
Structural – SEM Cavern	1	MM	Cleveland / RCTC offices
Civil – Roadway	4	Sub	RCTC
Civil – Utilities	120	MM & Subs	RCTC / Mississauga offices
Civil – Traffic Poles/Fdns	2	MM	RCTC

*TABLE 2 – CIVIL 3D MODELS*

The progress of the project can be followed on the Metro website:

<https://www.metro.net/projects/connector/>

## Understand the Revit Limitations

Revit 2014 has a 20 miles radius limit from its project base point. All the model data needs to be inside this limit, to avoid performance issues. The survey file provided for the RCTC project had its origin (its 0, 0, 0 point) more than 20 miles away from the location of the project. Civil 3D files were able to be brought into Revit, by shared coordinates, but warning messages were generated while doing that. A solution had to be found, before more serious issues and loss of data were to happen. Since the Civil 3D files couldn't move their 0, 0, 0 (the files needed exact x, y, z coordinates for construction coordination), the approach was to create a new survey file, with the origin closer to the project location, and use the new survey file to set-up the shared coordinate system in Revit. The downside of this was that every Civil 3D file that needed to be linked into Revit had to be moved into the Revit coordinate system before being linked. Also, because the Revit files were not in the same coordinate system as the Civil 3D files, they had to be moved into the real world coordinate system before being brought into Navisworks, for clash detection.

This issue between the coordinate systems and the conversions of the files from one system to another created a lot of extra work weekly.

## Bringing Civil 3D Content into Revit

Most of the Civil 3D files that were brought into Revit were utilities (existing, advanced relocated, proposed). This totaled approximately 120 utilities models. The civil design team would update the models, create a clean file of the model, purged of xrefs, then the Mott MacDonald BIM Coordinators would “convert” the clean utility model into a usable Revit file. Initially, the file was simply located into the Revit coordinate system, uploaded to ProjectWise, and linked as a CAD file. The individual utility networks displayed with good results in 3D views, but when sections were cut through the utilities, elements of the 3D geometry were displayed as simple lines, as you can see below, limiting the functionality of these elements.

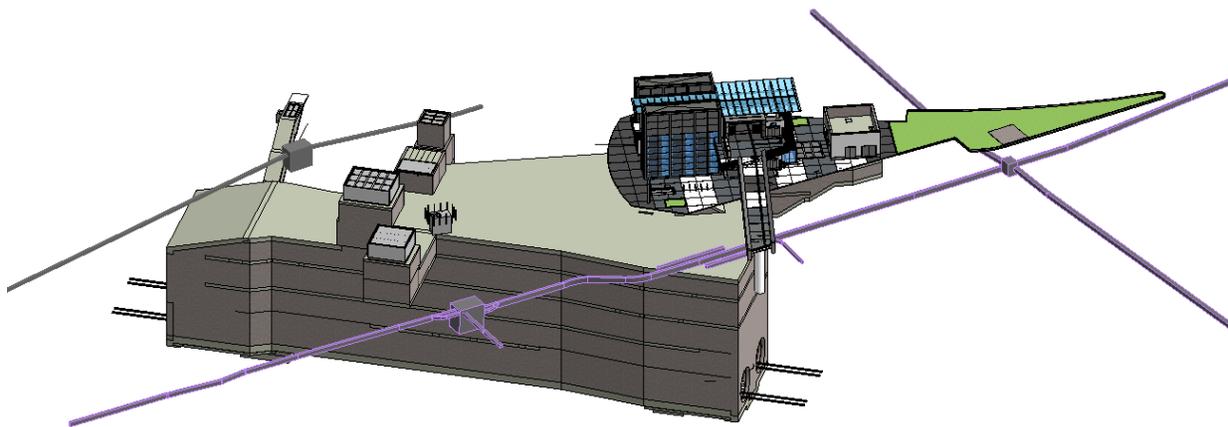
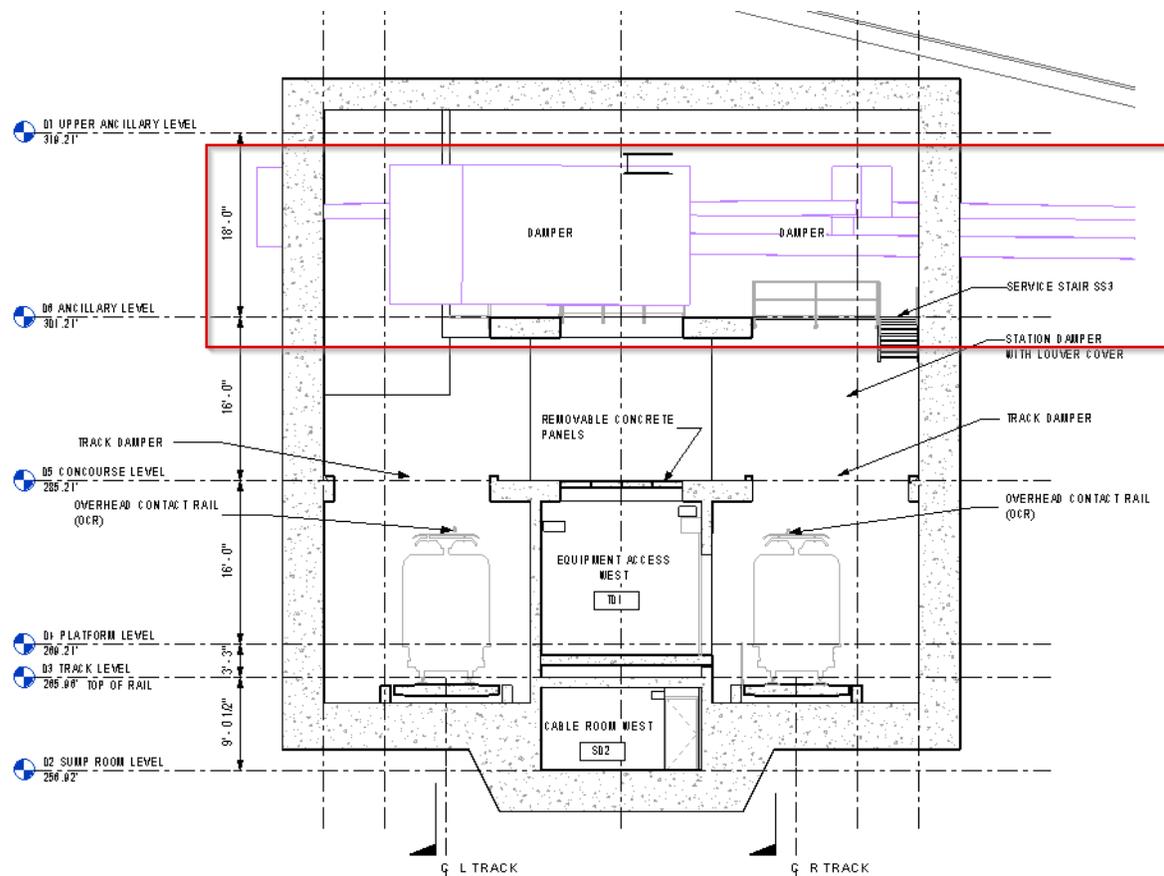


FIGURE 3 – 3D VIEW OF PIPE NETWORK



*FIGURE 4 – SECTION CUT OF PIPE NETWORK*

After some research, and a few abortive attempts, we discovered that the best way to handle the utility networks from Civil 3D was to import them into a Revit family. Each utility file was moved into the Revit coordinates first, and then inserted into a Revit family, which was loaded into a Revit file. The reasoning behind this was the enhanced control over the exact location of the utility by loading it into a Revit file that could then be linked in any other model, by shared coordinates. To minimize system overhead, instead of bringing all the utilities in a single Revit file, they were split into 9 distinct files: 3 stations, each of them dealing with 3 types of utilities (existing, advanced relocated, proposed). This approach ensured that each of the stations needed only to reference the utilities relevant to their respective portion of design.

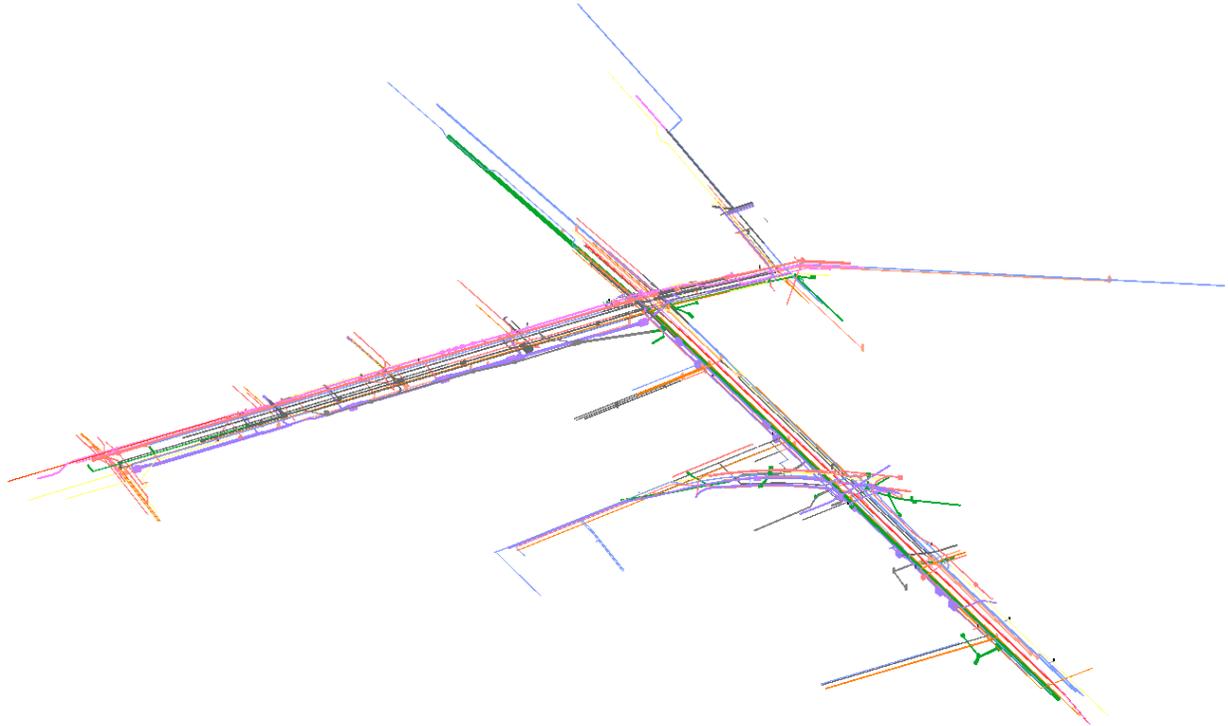


FIGURE 5 – 1<sup>ST</sup>/CENTRAL STATION EXISTING UTILITIES

## Bringing AutoSprink Content into Revit

Handled by the contractor's sub-consultant, the fire protection design for all three stations was completed using the AutoSprink design software. In order to coordinate and facilitate the design between disciplines, a method of bringing the fire protection model into Revit needed to be developed by Mott MacDonald. The challenge was AutoSprink models are created using "real world coordinates", while Revit models were linked by "Revit coordinates" (the new origin point). The designer would export .mrv files from the AutoSprink, one file per level of the station, and then this .mrv file was imported into a Revit file. The individual Revit files (one for each level) were then linked into the master Revit file, and this file was used by the other disciplines to link into their models for coordination.

The .mrv files had a reference point at the location of the Revit origin, so positioning the individual Revit files in the right location within the master Revit file was easy (the reference point in the .mrv files had to overlap the Revit origin).

At each update to the fire protection model, the designer would have to repeat the export and import process.

## Bringing Revit Content into Civil 3D

Civil 3D cannot reference Revit models. A 3D .dwg export system was created so design information was interchangeable between Revit and Civil 3D.

### Step 1: Export 2D Xref from Revit

For each of the 3 stations, .dwg files of the overall floor plans and a few sections were exported. These exports were set to a weekly schedule with the provision of more frequency, as required by design challenges and milestones.

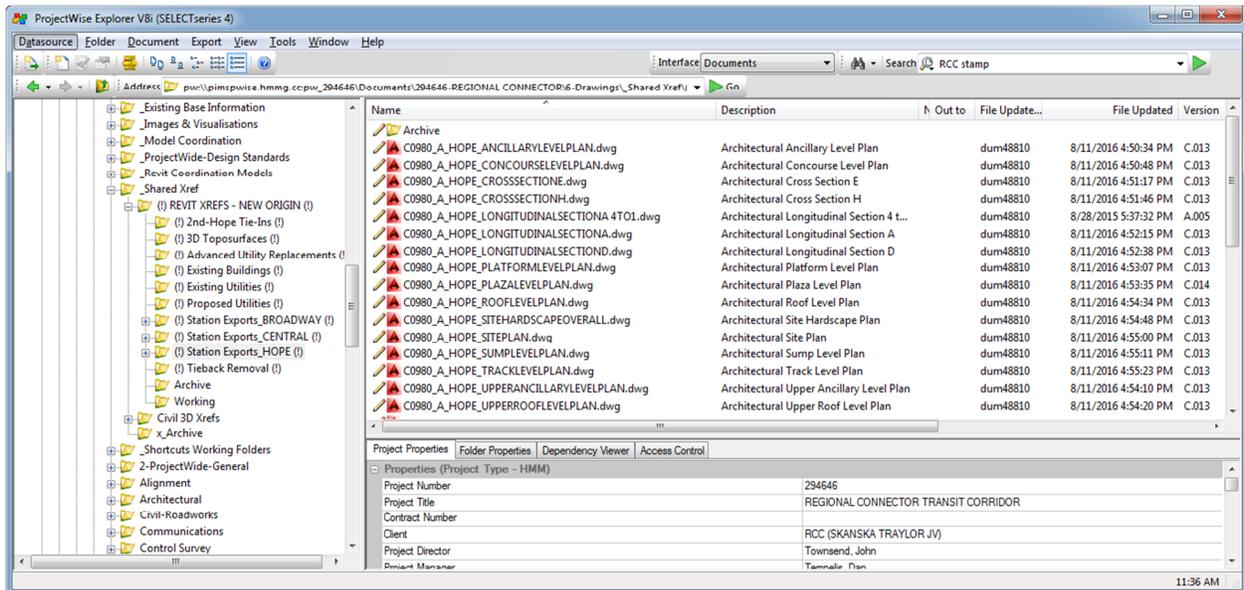


FIGURE 6 – 2<sup>ND</sup>/HOPE .DWG EXPORTS

### Step 2: Import 2D Xref into Civil 3D

These .dwg files were then xref-ed in Civil 3D.

## Revit – ProjectWise Workflow

ProjectWise and Revit are not known for working well together, especially on a project of this scale. A few months into the project, it was decided to move 13 of the 15 models to a local server to maximize performance and minimize bandwidth latency. The remaining two continued to be stored on ProjectWise due to logistical pressures of remote offices working on the files simultaneously. The local modelers uploaded the latest version of their model in ProjectWise daily, to increase design coordination with the other disciplines. So it was almost as if the models were “live” in ProjectWise.

In order to improve the Revit functionality, both for the ProjectWise models and the ones on the local server, the following were implemented:

- Proper use of the worksets: each linked model/CAD file on its own workset, different worksets for different categories of objects, check out/close worksets.
- Unload any unused links before closing the model.
- Purge the models of unused family content.
- Compress the Revit file to reduce its size. Revit's file is highly compressed and once opened Revit expands the size to approximately twice the size. Occasionally Revit fails to compress the file as it exits!
- Delete any unused model and detail groups.
- Try to make all/most dwg information linked rather than imports in Revit. Importing dwg will push the file size up by the size of the dwg. Links are more beneficial, but in all cases dwg information that is no longer required should be removed. Also, unloading linked dwg files will speed Revit up.
- Close all hidden windows. If Revit requires the model to regenerate it will do so in all current opened views, therefore reducing the number of opened views will reduce the number of regens.
- Turn off categories/sub-categories where they are not required.
- Solve as many warnings as possible.

## How Has the Technology Helped?

BIM was the right approach for the project. The main benefits of using BIM on the Regional Connector Transit Corridor project were:

- All disciplines were able to reference other disciplines models for design coordination
- Model changes were captured in all drawings simultaneously (plans, sections, elevations, details)
- Conflict resolution was expedited with the ability to see elements in 3D
- Multiple users worked in a single model (Revit model), increasing efficiency

With the use of BIM, Mott MacDonald's client relationships with both the contractor RCC and the project owner LA Metro improved. Metro's previous CAD standard files were adapted into 3D elements that were used throughout the project. To support Metro's sustainability initiatives, the Metro's QA Group was granted limited access to ProjectWise to perform their QA responsibilities on the design submittals in a paperless environment. Partly due to the success of the RCTC project and Mott MacDonald's demonstration of the models' power and usefulness, BIM has now become a Metro standard requirement on future transit projects.

## Issues and Their Resolution

As with any innovative project though, a few issues surfaced during the mobilization phase, but solutions were investigated, identified and implemented to ensure that there were no delays to the fast-paced final design schedule.

Some of them have already been highlighted in the sections above.



- Issue: ProjectWise and Revit are not known to work well together, especially on a project this scale

Resolution: 13 of the 15 Revit models were moved from PW to a local server to maximize performance and minimize bandwidth latency

- Issue: Civil 3D cannot reference Revit models

Resolution: a 3D .dwg export system was created, so design information was interchangeable between Revit and Civil 3D (still required manual sync once or twice a week)

- Issue: Multiple users in multiple offices with different approaches, not always aligned with the team's rules

Resolution: Strong project office based BIM/CAD management team, constant "policing", ongoing training

## Regional Connector Transit Corridor – Award Winning

RCTC was one of the first linear projects designed in BIM within Mott MacDonald. Despite the few bumps in the road highlighted throughout this handout, the project was a success, and earned a few mentions and awards within the company and outside of it. The ones worth mentioning are:

- Team Excellence Award in the Mott MacDonald Technical Excellence Award 2016
- Special Commendation in the Mott MacDonald BIM Awards 2015
- Article in the October 2015 issue of Momentum (internal magazine)
- Article in the September 2015 issue of Perspectives (internal magazine)
- Presentation of the project at the February 2015 ASCE LA Chapter
- Feature in the December 2014 American Society of Civil Engineers (ASCE) Magazine

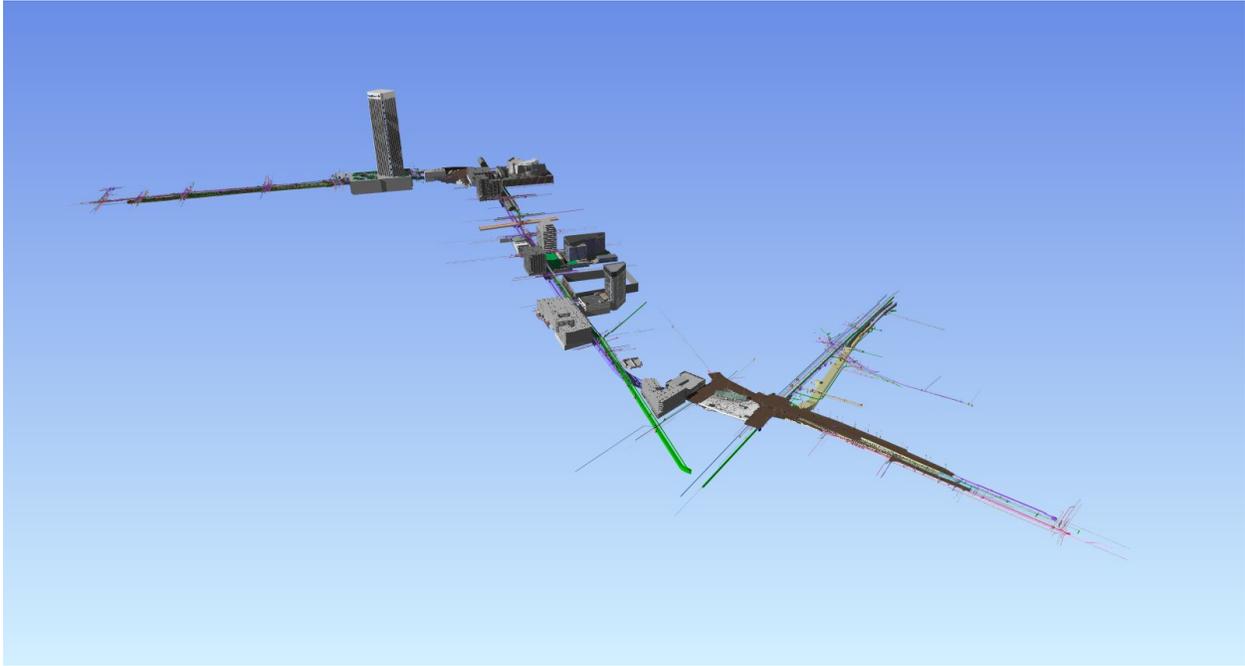
## The Future of the Unicorn

A project as complex and large as Regional Connector Transit Corridor could be delivered more efficiently if software from different platforms and even from the same platform would communicate better.

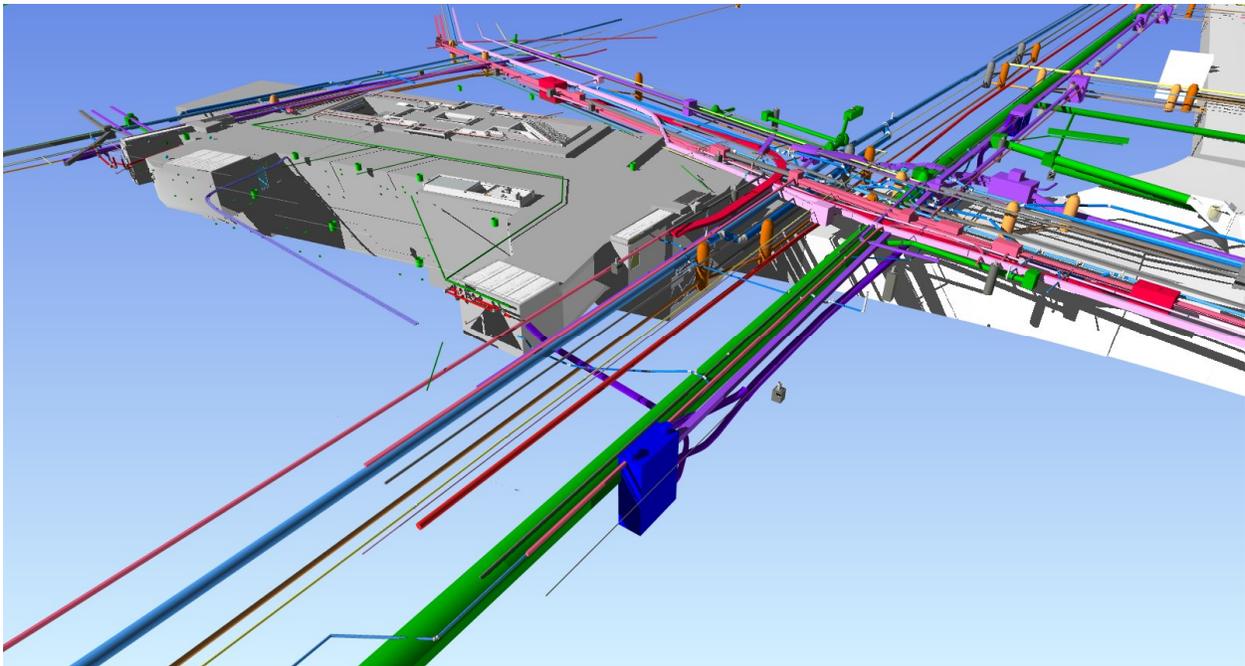
Does the Unicorn have a future? Definitely. If some, if not all of the issues RCTC had to battle would be solved. This is a wish list that most of the BIM enthusiasts have.

- The Revit coordinate system should be easier to set-up, without any 20 mile limits. Linear projects extend for more than 20 miles sometimes.
- Civil 3D should be able to reference Revit models, without any exports involved.
- Revit should be able to link Civil 3D files directly without any loss of geometry.
- Revit and ProjectWise should be able to work well together, so disciplines can reference each other's models "live".

## Project Images



*FIGURE 7 – OVERALL PROJECT*



*FIGURE 8 – 1<sup>ST</sup>/CENTRAL STATION & UTILITIES*

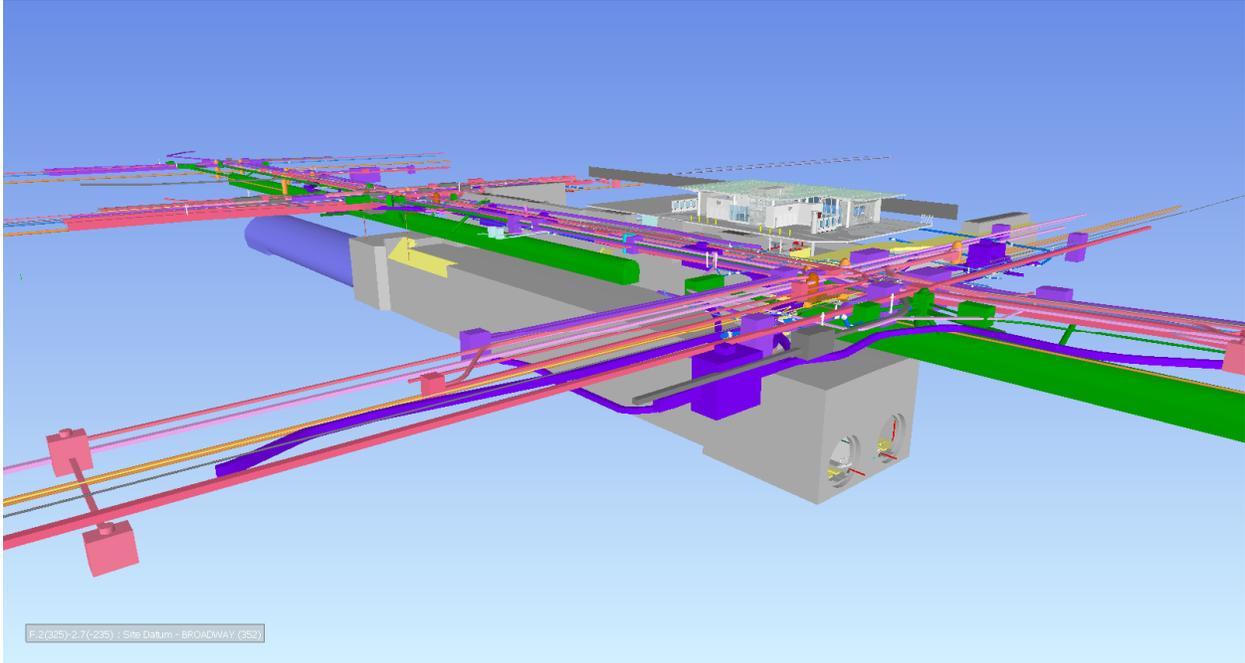


FIGURE 9 – 2<sup>ND</sup>/BROADWAY STATION & UTILITIES

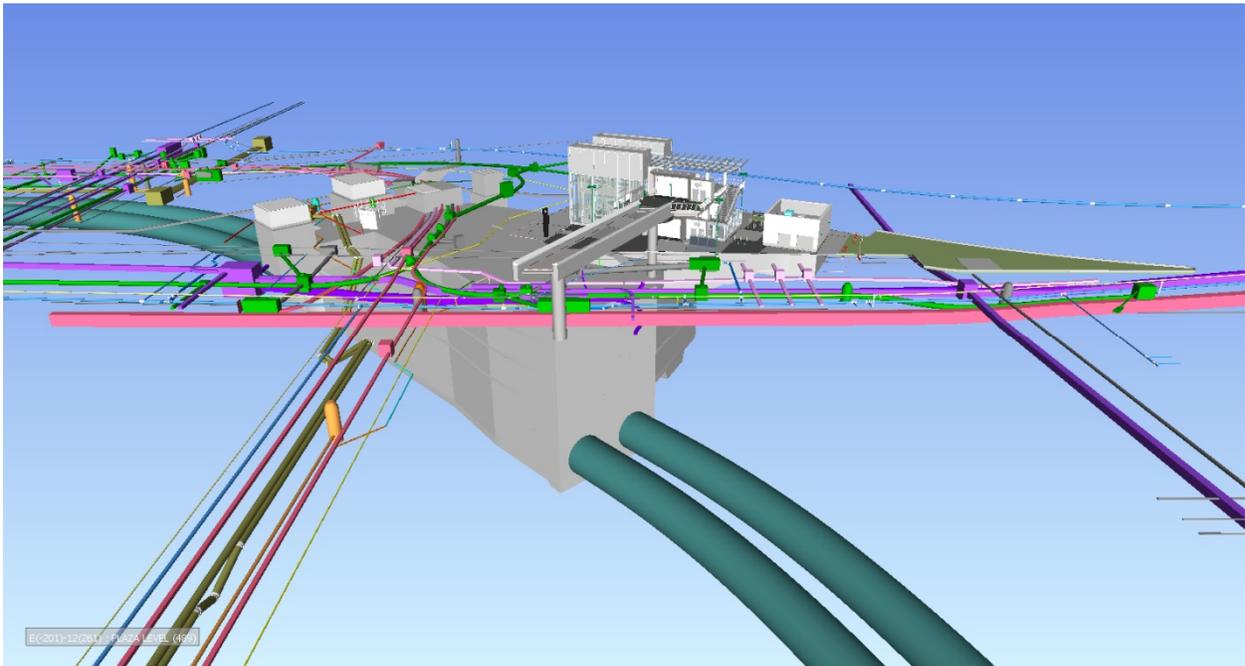


FIGURE 10 – 2<sup>ND</sup>/HOPE STATION & UTILITIES

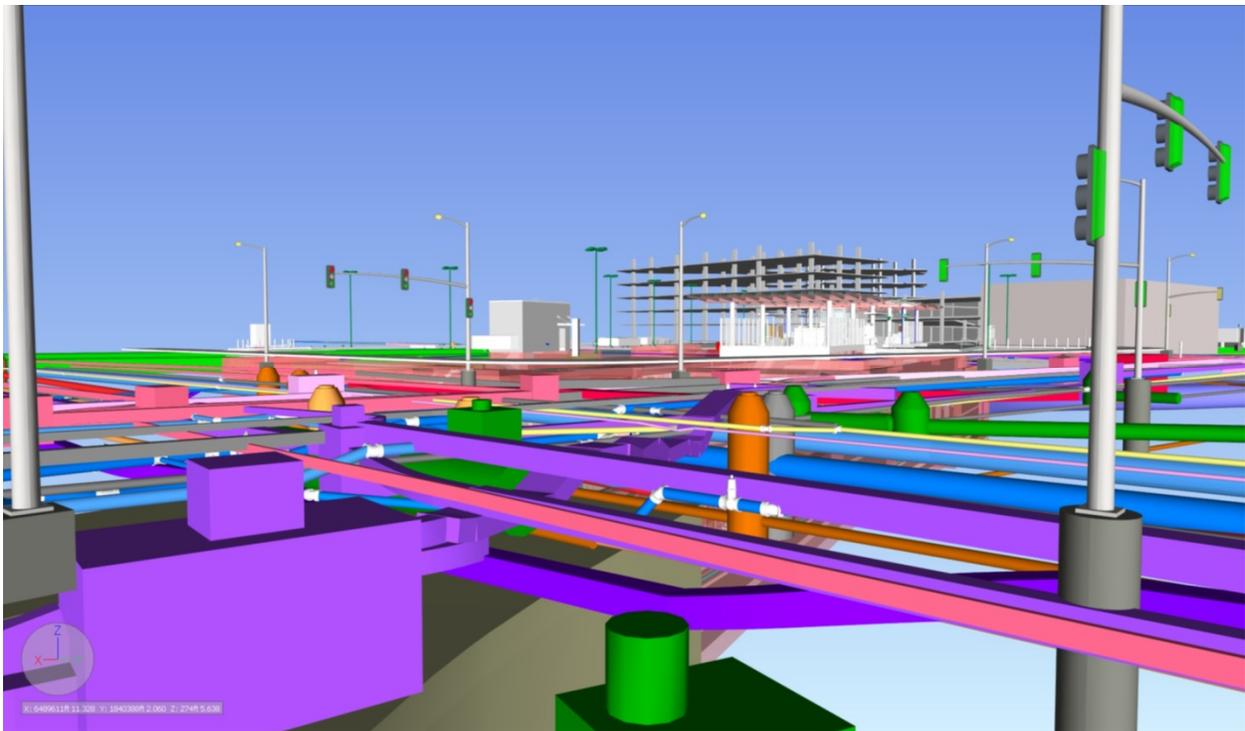


FIGURE 11 – 1ST/STREET & ALAMEDA

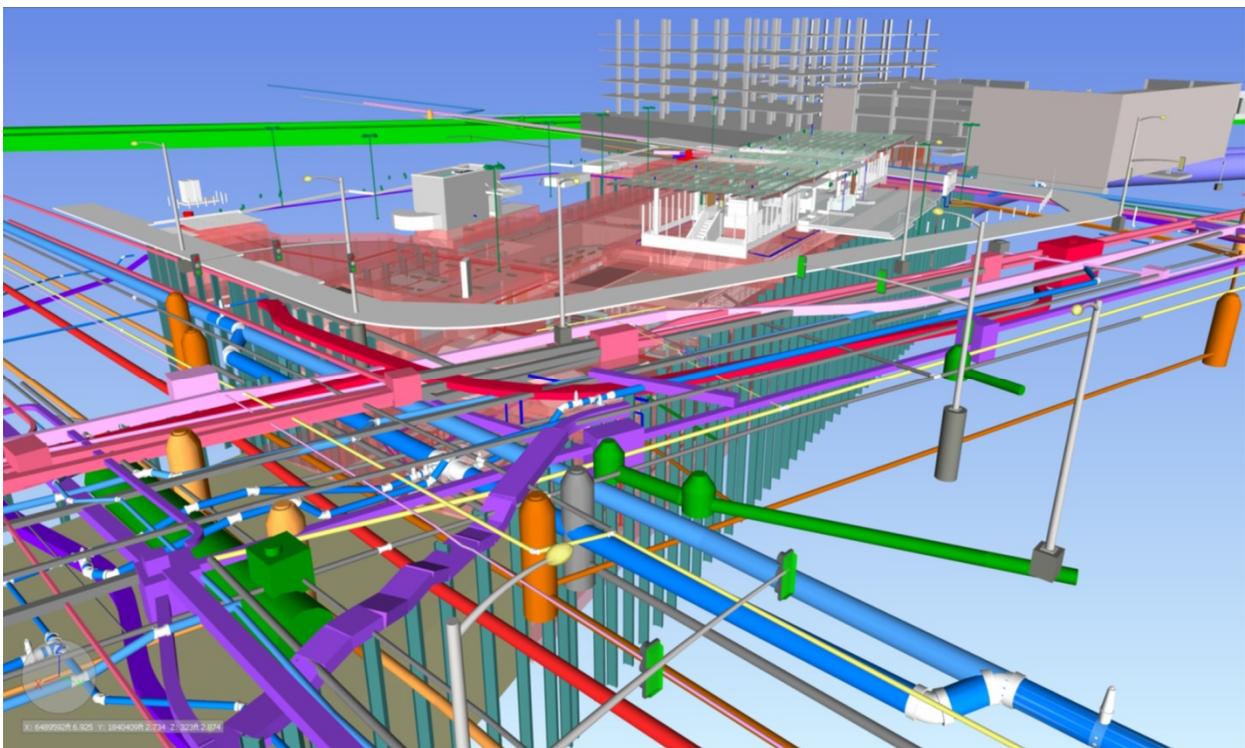


FIGURE 12 – 1ST/CENTRAL STATION SOE & UTILITIES

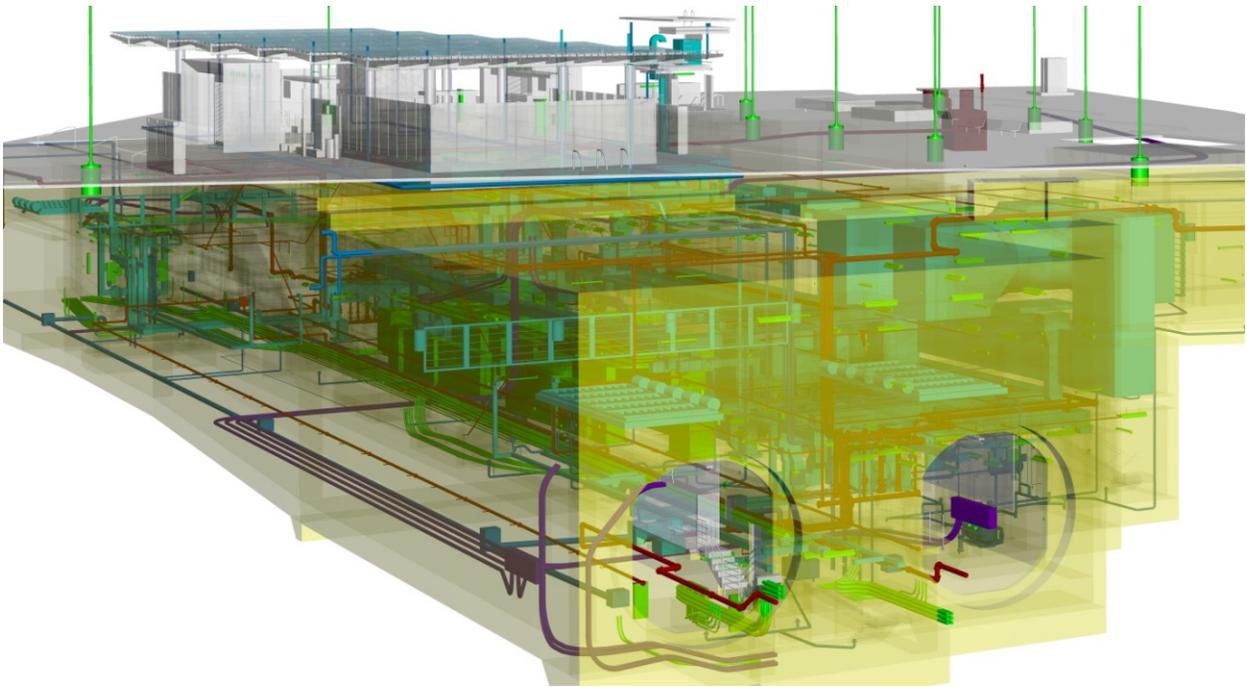


FIGURE 13 – 1ST/CENTRAL STATION

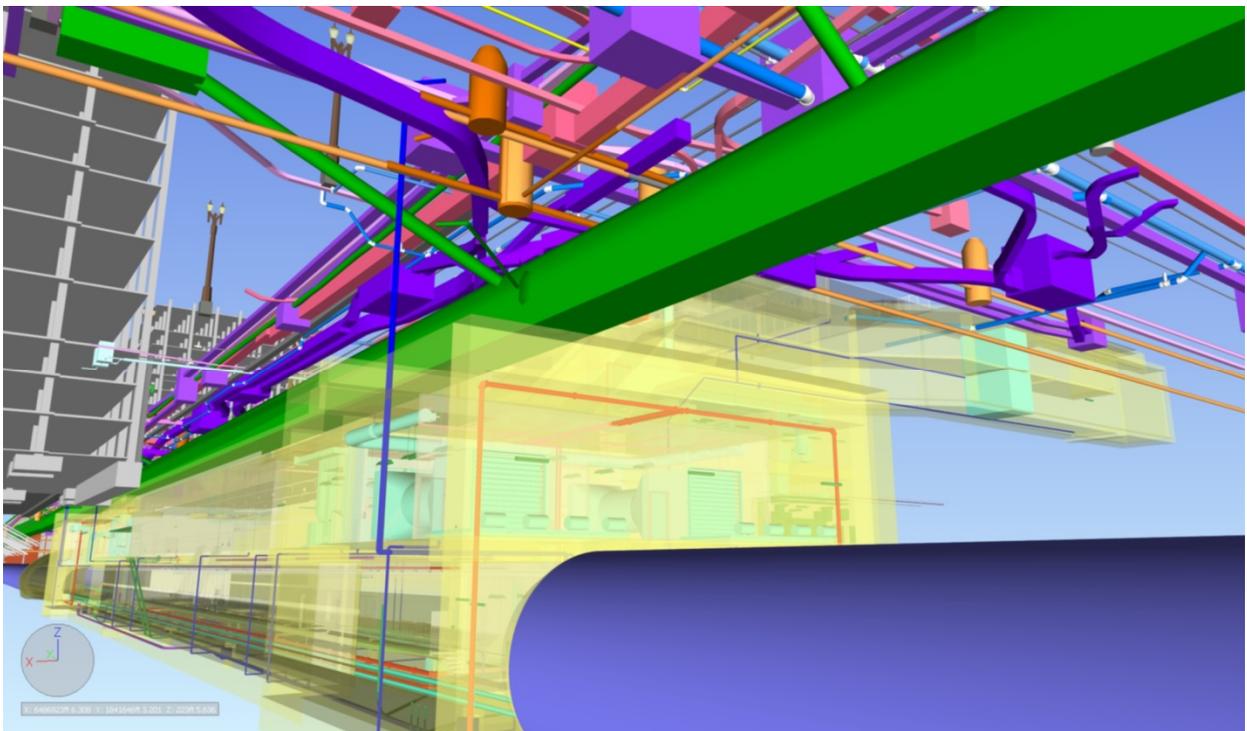
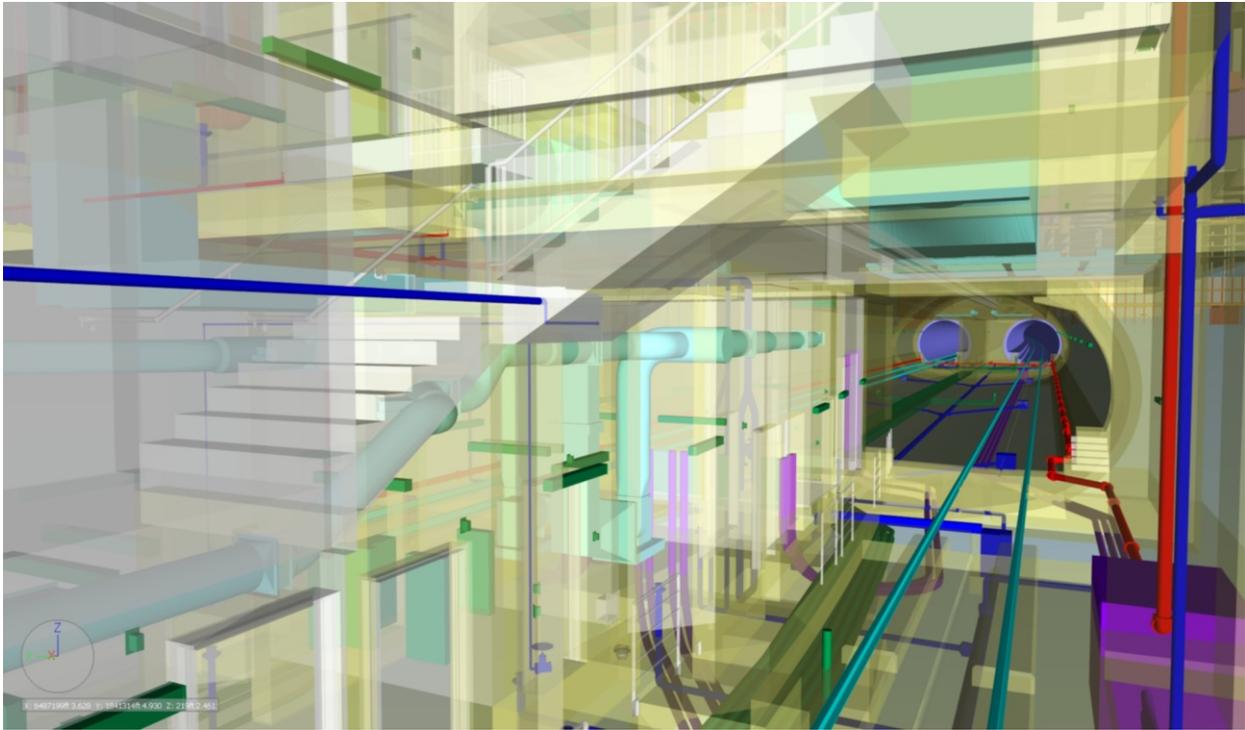
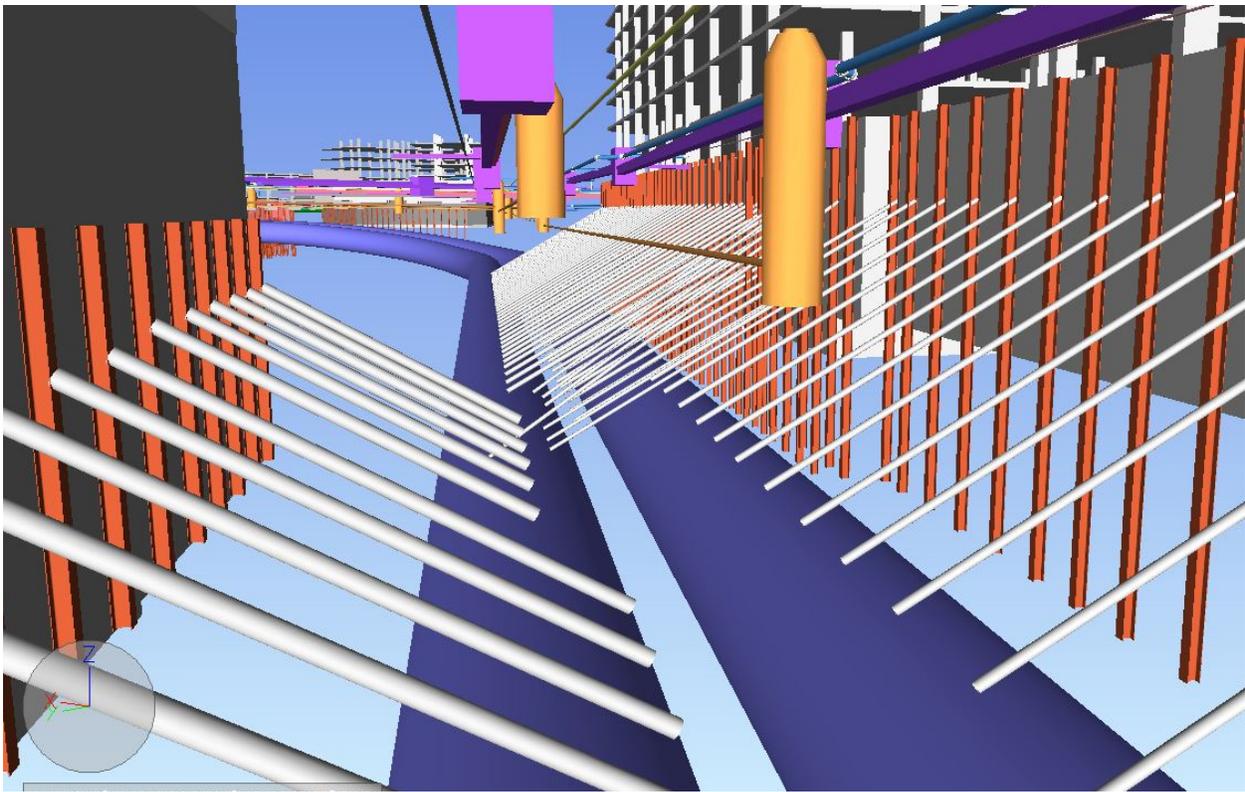


FIGURE 14 – BORED TUNNELS INTO 2ND/BROADWAY STATION



*FIGURE 15 – INSIDE 2<sup>ND</sup>/BROADWAY STATION LOOKING AT SEM*



*FIGURE 16 – BORED TUNNELS AND TIEBACKS*

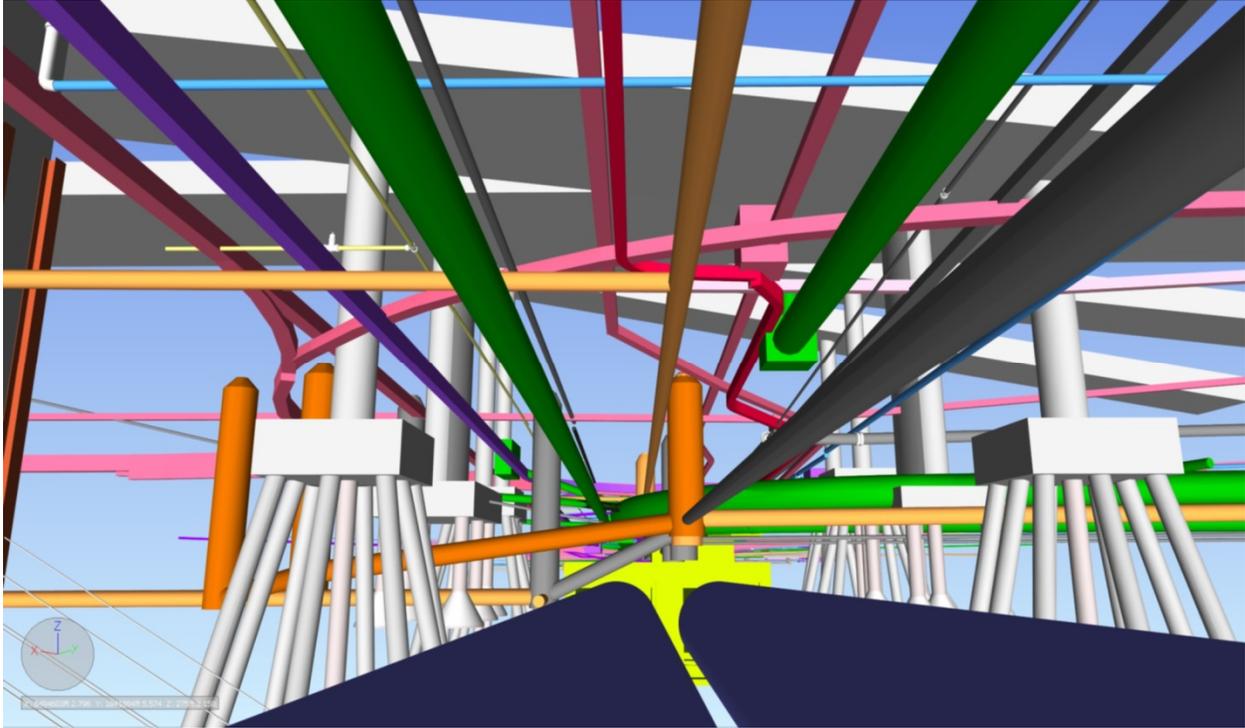


FIGURE 17 – 4<sup>TH</sup> STREET BRIDGE



FIGURE 18 – 2<sup>ND</sup>/HOPE STATION LOWER LEVEL



*FIGURE 19 – 2<sup>ND</sup>/HOPE STATION UPPER LEVEL*



*FIGURE 20 – 2<sup>ND</sup>/HOPE STATION EXTERIOR*